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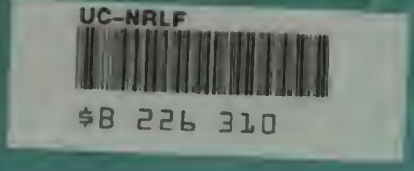

NAVPERS 93083A-1

TROUBLESHOOTING ELECTRONIC EQUIPMENT

TROUBLESHOOTING PRINCIPLES

VOL. 2

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FOREWORD

This text was developed by the Chief of Naval Personnel for use in schools that provide instruction in troubleshooting electronic equipment.

Since it is written in a programed-learning format, the text can also be used by individuals or groups on ships or activities where no formal training is conducted.

M. D. GASTROCK
Captain, U.S. Navy
Director, Instructional
Standards and Materials
Division
Bureau of Naval Personnel

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PREFACE

This is volume 2 of NavPers 93083A, Troubleshooting Electronic Equipment, and provides the reader with practice in applying the six-step procedure outlined in volume 1. This portion further provides the reader with an excellent opportunity to become acquainted with a standard oscilloscope. If possible it is recommended that the reader utilize the oscilloscope by making the actual checks and control manipulation outlined in Lessons 1, 2, and 3.

The pages of this book are arranged in a scrambled form and the book cannot be read in the usual manner. After each block of information, questions are asked to immediately test you on the subject matter contained in the information block. Several answers are provided and you must pick one answer as your choice. Near each choice is a page number indicating the page on which you can find out whether this choice is correct or not. An incorrect answer results in further discussion of the subject, providing additional information which will aid you in making the correct choice. A correct answer leads you further along in your study.

When ordering this publication, request NavPers 93083A-1, 93083A-2, and 93083A-3 to obtain the complete set.

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LESSON NO. 1

INTRODUCTION TO TROUBLESHOOTING ANALYSIS

USE OF THE AUTOMATED TEXTBOOK

Before starting to read this textbook, be sure to read the PREFACE on page v.

This textbook is specifically designed to aid you in learning to use the most valuable tool (Six-Step Logical Troubleshooting Procedure) you will ever have in troubleshooting and maintaining electronic equipments of any type. As was mentioned in the introduction, this text is not an ordinary type of book; the pages are numbered in sequence, but this is not the way the book is intended to be read. This is an Automated Text wherein you study by direction.

By reading a particular information bit or block, you should understand the information that is presented. To check your understanding of the information, a question with several possible answers is given at the end of the information block. Choose one answer; then turn to the page listed after that answer and find out whether you are correct or incorrect in your choice. If you are correct, you will be told to continue your study. If your selection is incorrect, you will be provided with additional information using a slightly different approach. After reading the additional information you will be told to return to the pages from which you were directed, in order that you may read them again and study certain points more closely.

You have just completed your first information block in this book. After completing an information block, how do you get to the next information block?

SELECTIONS:

A. Turn to the next page. (page 2)

B. Turn to the page indicated after any answer selection I choose (page 7)

C. Turn to the page indicated after the correct answer selection. (page 4)

from page 1

YOUR SELECTION:

A. Turn to the next page.

W-A-R-N-I-N-G

If you turned to this page from page 1, you did not follow the directions for using the Automated Text. It was pointed out, in the PREFACE and in the first topic of this lesson, that this is not an ordinary book which flows from one page to the next in numerical sequence. The pages are "scrambled"; so be alert and follow the direction given. Re-read the PREFACE and USE OF THE AUTOMATED TEXTBOOK, page 1; then begin anew.

from page 4
YOUR SELECTION:

A. Yes, this is true

Excellent. You have demonstrated a complete understanding of how to follow the directions and indexing marks in this book so that you can progress through the text and understand its contents.

Since the book is written in a scrambled format, you cannot turn back two or three pages to restudy or verify the previous information. So that you will be able to review when necessary, the notation "from page --" is listed at the top of each page. This will aid you in returning to the previous block of information.

Let's try one more question before going on to the troubleshooting problem. If you were in doubt about what the previous block of information had stated concerning a specific point, how would you go about checking the information?

SELECTIONS:

A. Turn to the previous page. (Page 9)

B. Turn to the page indicated at the top of page I was reading (Page 10)

C. Turn to the index. (Page 5)

from page 1
YOUR SELECTION:

C. Turn to the page indicated after the correct answer selection.

Excellent. The correct answer refers you to the next information block in your learning process. However, only the correct answer will do this. An incorrect answer will refer you to a page which will, in turn, refer you back to the information block you just studied, in order that you may re-study that information.

The sequential page number at the bottom of the page is the same as that employed in any book. However, it does not give you the sequence of pages as far as reading and studying are concerned--these numbers merely help you to locate pages referred to by the text material.

Is it true that the number at the bottom of the page in this book is included only to help me find a specific page referred to by text material?

SELECTIONS:

A. Yes, this is true (Page 3)

B. No. this is not true (Page 6)

C. These page numbers are not used in locating information (Page 8)

from page 3

YOUR SELECTION:

C. Turn to the index.

No. Nothing has been said about an index. In fact this book does not even have one. The table of contents wouldn't be much help either since it would only tell you on what page a particular lesson started.

Restudy page 3 and then select the correct answer.

from page 4

YOUR SELECTION:

B. No, this is not true.

The sole purpose of the sequential number at the bottom of each page is to aid you in finding a page referred to by text material. These numbers are of no value what-so-ever in telling you how to advance your learning process.

Re-study page 4 before selecting another answer to this question.

from page 1
YOUR SELECTION:

B. Turn to the page indicated after any answer selection I choose.

No. Only one answer will lead you to the next block of information. If the selection you choose is an incorrect response, you will be provided with additional information to aid you in further understanding the material. You will then be directed to reread the original presentation before making another choice.

If the correct response to each question is choosen, the reader can proceed uninterupted through the text. Therefore, it is important that each block of information be studied carefully so that the correct choice can be made.

Reread the PREFACE, and page 1, USE OF AUTOMATED TEXTBOOK before selecting another answer.

from page 4
YOUR SELECTION:

C. These page numbers are not used in locating information.

There is a definate purpose for each index mark and page number used in the book. Sequential numbers follow the numbering system used in the ordinary book and provide rapid means of locating a particular page.

Re-study page 4 before selecting another answer.

from page 3

YOUR SELECTION:

A. Turn to the previous page.

Definitely not. You have missed the point completely. This book is written in a programed format and the instructions on each page must be followed exactly if you are to progress efficiently.

Restudy page 3 and then select the correct answer.

from page 3
YOUR SELECTION:

B. Turn to the page indicated at the top of the page I was reading.

Good. You have made the correct choice. The page number listed at the top of each page will direct you back to the previous block of information.

Now that you are familiar with how the automated text works, turn to page 11 and commence lesson 2.

from page 10

LESSON 2

TROUBLE-SHOOTING PROJECT NO. 1

The reader should become familiar with NavPers 93083A-3, Troubleshooting Electronics Equipment, Volume 3 prior to beginning this lesson.

The TS-O is a general-purpose oscilloscope designed to perform a number of testing operations, including alignment of receiving and transmitting equipment (radio and radar), hum measurements, frequency comparison, observing of standard and complex signal voltage waveforms, percentage modulation, etc.

The basic operational function of the TS-O, like that of any other oscilloscope, is the visual representation of an electrical input signal or combination of electrical input signals. The visual conversion is accomplished by the cathode-ray-tube section. A beam of electrons is focused on a phosphor-coated screen, which glows when excited by the electrons. The beam can be focused to form a very small spot on the screen surface. The desired signals are applied to two sets of deflection plates, each set consisting of two parallel plates. The two sets are arranged with their axes mutually perpendicular so that a signal applied to one set will deflect the spot horizontally, and a signal applied to the other set will deflect the spot vertically. These three conditions are shown in figure 32, page 13. Part A shows a focused spot—the condition which occurs when the oscilloscope is turned on but no deflecting signal is applied to either set of plates. The position of this spot on the screen is controlled by the vertical positioning control and the horizontal positioning control. In part B a deflecting signal is applied only to the horizontal plates. This sweeps the spot across the screen, producting a horizontal trace. The horizontal trace can be moved up or down and to the right or left by means of the vertical positioning control and the horizontal positioning control, respectively. Part C shows a vertical trace, produced when a deflection signal is applied only to the vertical plates. This trace can also be moved about on the screen by means of the positioning controls as described above for the horizontal trace.

Viewing a horizontal or vertical trace alone does not tell us much about an applied signal. For this reason, the two sets of deflection plates must be used in combination. To provide a visual trace of a waveform which varies with time, a controlled time base signal is applied to the horizontal plates. This waveform is usually generated by the sweep oscillator, although an external signal may be used. The rate

(continued on next page)

from page 11

at which the beam sweeps across the screen can be controlled by the coarse and vernier frequency switches when the horizontal attenuator switch in on SWEEP (the time base is generated by the internal circuitry). These controls are shown in figure 1, page 29-30, of the TS-O manual.

If the desired signal is applied to the vertical plates at the same time the time base signal is applied to the horizontal plates, the spot will continue to sweep across the screen at the controlled rate. However, it will also be deflected vertically by an amount proportional to the voltage applied to the vertical plates. The resultant effect is a "picture" of the desired signal, as shown in figure 3 and 4 pages 6 and 7 respectively of the TS-O manual. The exact conditions for producing these various waveforms are discussed in paragraph 3 (OSCILLOSCOPE OPERATIONAL TECHNIQUES), on page 5 of the manual. Study this paragraph so that you will become more familiar with the operational function of the TS-O.

The TS-O is a single unit set. Refer to the functional block diagram in figure 6, page 31-32, of the TS-O manual, to determine the function of each block. Study paragraph 1 on page 11 of the TS-O manual to become familiar with the purpose of each sub-function.

When you report for work, you find a TS-O on the bench with a report filled in by someone on a previous shift. He had tried to use the instrument and found that there was no vertical deflection for either an a-c or d-c vertical input signal. He did not have time to check the instrument further.

What is the first step you should take in order to return the TS-O to serviceability?

SELECTIONS:

A. Perform the necessary control manipulations in order to elaborate upon the symptom. (Page 21)

B. Verify the trouble symptom. (Page 27)

C. Remove the set from the case and connect a signal to the vertical amplifier. (Page 34)

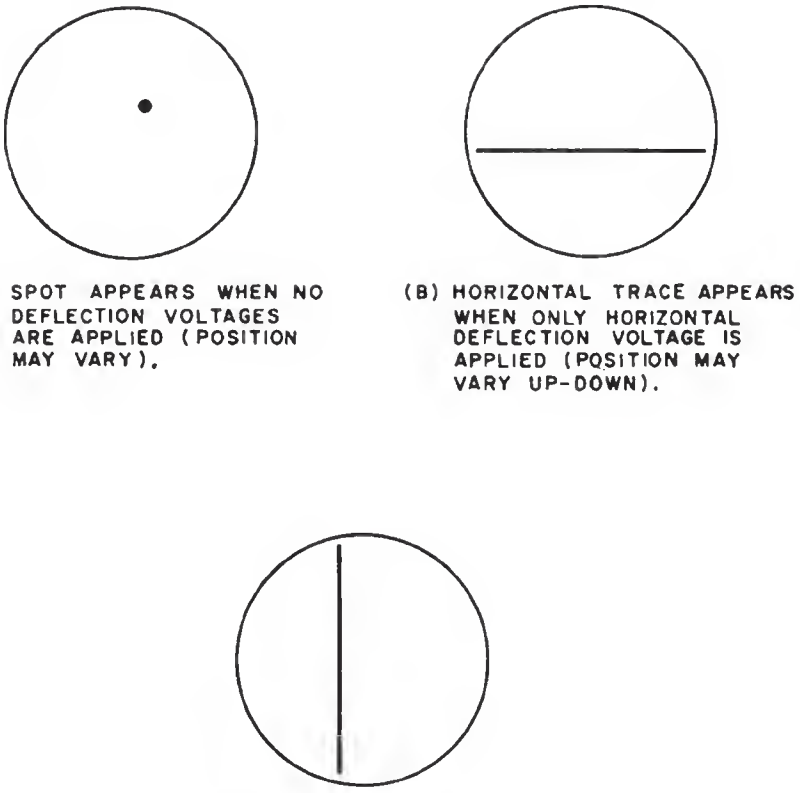
(A) SPOT APPEARS WHEN NO DEFLECTION VOLTAGES ARE APPLIED (POSITION MAY VARY).
(B) HORIZONTAL TRACE APPEARS WHEN ONLY HORIZONTAL DEFLECTION VOLTAGE IS APPLIED (POSITION MAY VARY UP-DOWN).
(C) VERTICAL TRACE APPEARS WHEN ONLY VERTICAL DEFLECTION VOLTAGE IS APPLIED (POSITION MAY VARY LEFT-RIGHT).

Figure 32. Special Oscilloscope Presentations

from page 23

YOUR SELECTION:

A. Between the input to the vertical amplifier and test point B.

No. You not only selected the wrong test point, but you also failed to interpret the test result correctly. The waveform obtained at test point B is almost exactly the same as the one shown in the manual. This definitely indicates that the trouble is beyond this test point. Making a check at test point B has eliminated only the cathode follower and one section of the vertical attenuator. Remember, all test points should be selected to eliminate as many circuits as possible.

Return to page 28 and select the correct answer

from page 30

YOUR SELECTION:

C. Cathode-ray tube.

No. If the Cathode-ray tube was at fault, there would be no visible trace on the face of the scope. The horizontal sweep, shown in figure 33, should have eliminated this as a possible trouble.

Reread page 30 and select a more logical answer.

from page 28

YOUR SELECTION:

C. Test point D.

Wrong. A check at test point D would not be the best choice. You should have recalled that a prime consideration when making your test, is to eliminate as many circuits as possible. Checking at test point D would isolate the 2nd. DC amplifier and half of the 1st. DC amplifier.

Reread page 28 and select a more logical choice.

from page 40

YOUR SELECTION:

A. The touble is in the horizontal amplifier.

No. The test results indicate that the outputs of this circuit group are identical in shape to those in the servicing block diagram. The amplitudes of the test waveforms are somewhat low; however, because of tolerances in resistors, vacuum tubes, and adjustments, this amount of deviation is not excessive. The pattern on the TS-0 Display Circle indicates that the horizontal trace is normal. You should have eliminated the horizontal amplifier as a possible trouble area when you saw this horizontal trace. A test of this circuit group was unnecessary.

Reread page 30 and make a more logical choice.

from page 31

YOUR SELECTION:

B. Between test point C and the output of the vertical amplifier.

No. You selected the correct test point to make this check; however, you failed to analyze the test results properly. It should have been obvious that the signal was missing entirely at test point C, and, therefore, that the trouble must be ahead of this point.

Return to page 31 and select the correct answer.

from page 40

YOUR SELECTIONS:

C. The trouble is in neither the horizontal amplifier nor the power supply.

Correct. You have recognized the fact that the test results indicate proper operation of the horizontal amplifier, and this in turn indicates that the power supply must be operating correctly. However, you made a mistake when you made your selection of possible faulty circuit groups. The original symptoms show that the horizontal trace is normal. Making the wrong selection has resulted in an unnecessary test of the horizontal amplifier.

Reread page 30 and select a more logical choice.

from page 25

YOUR SELECTION:

A. Cathode follower.

No. The trouble is present when the d-c input is used, which bypasses the cathode follower. A trouble in this circuit would affect the operation only when the vertical attenuator is in the a-c positions.

Return to page 25 and select the correct answer.

from page 12

YOUR SELECTION:

A. Perform the necessary control manipulations in order to elaborate upon the symptom.

No. We do not question the integrity or the ability of the technician who made the report. However, anyone can make mistakes, and, if you accept the report at face value, his mistake might cost you a lot of time which could be spent repairing some other piece of equipment.

Always verify trouble symptoms.

Reread pages 11 and 12 then select a more logical answer.

from page 29

YOUR SELECTION:

B. Vertical attenuator.

Yes. The over-all schematic in Figure 18, pages 51-52 of the TS-O manual, shows that the vertical gain control electrically consists of two circuits, and their outputs are selected by the second part of the vertical attenuator. If R104A were defective, R104B would still control the vertical gain when the vertical attenuator is in the AC position. If R104B were defective, R104A would still control the gain when the vertical attenuator is in the DC position. It is unlikely that both potentiometers are defective.

What type of test should be performed to test the vertical attenuator switch?

SELECTIONS:

A. Resistance check. (Page 43)

B. Voltage check. (Page 37)

C. Signal injection (Page 45)

from page 28

YOUR SELECTION:

A. Test point B.

The waveform obtained at this test point is shown in figure 36.

Compare the waveform obtained in this test with the one shown in the servicing block diagram, page 53-54 of the manual.

The location of the trouble is given in one of the following selections.

SELECTIONS:

A. Between the input of the vertical amplifier and test point B. (Page 14)

B. Between test point B and the output of the vertical amplifier. (Page 41)

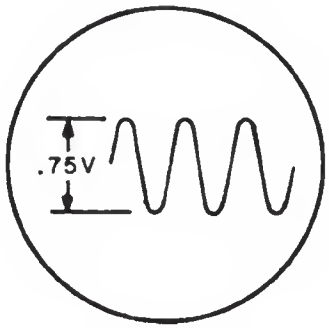

Figure 36. Waveform Obtained at Test Point B

from page 30

YOUR SELECTION:

B. Vertical amplifier

To check the operation of the vertical amplifier, the line test signal (E106 in figure 18, page 51-52 of TS-0 manual) is applied to the vertical a-c input (J 101) and another oscilloscope is connected to the output test points in order to obtain the waveforms. Figure 35 shows the waveforms obtained in this test. Compare them with the waveforms shown at the same test points on the servicing block diagram, page 53-54, of the TS-0 manual.

Considering these test results, which statement do you believe is correct?

A. The trouble is in the vertical amplifier. (Page 28)

B. The trouble is in the power supply. (Page 26)

C. The trouble is in neither the vertical amplifier nor the power supply. (Page 42)

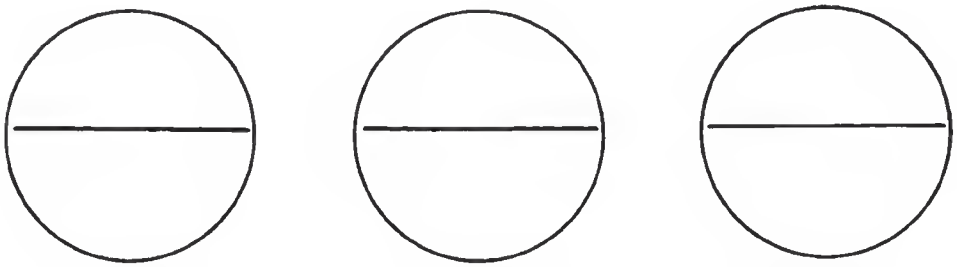

Figure 35. Output Waveforms for Vertical Amplifier

from page 31

YOUR SELECTION:

A. Between the input of the vertical amplifier and test point C.

Yes. You have selected the correct test point for this check, and you have analyzed the test results correctly. The output bracket at the vertical amplifier should be removed and one placed at test point C. Testing at point C not only applies the half-split method, but also makes it possible to employ the switching technique. In this test you apply input signals to both a-c and d-c vertical input terminals, and there is no output at test point C as the vertical attenuator is switched to all positions.

The location of the trouble is given in one of the following selections.

SELECTIONS:

A. Cathode follower. (Page 20)

B. Vertical attenuator or vertical gain circuits. (Page 29)

from page 24

YOUR SELECTION:

B. The trouble is in the power supply.

Wrong. The test results indicate that the outputs of the vertical amplifier are nonexistent. This could be caused by a faulty power supply. However, the horizontal trace on the screen of the TS-O is normal. The proper operation of the horizontal amplifier requires the same power supply voltages which are used by the vertical amplifier; therefore, the power supply should not be suspected as the trouble area.

Reread page 24 and select a more logical choice.

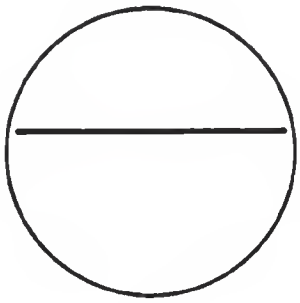

Figure 33. TS-O Display

from page 12

YOUR SELECTION:

B. Verify the trouble symptom.

Yes. This is always the first step to be taken for a malfunction which has been reported to you.

After the TS-0 has been plugged into the main power source, the intensity-power-on switch has been turned on, the pilot lamp is lighted, and sufficient warm-up time has passed, you view the screen and see the trace produced in figure 33, page 16 . You next apply an a-c signal to J101, figure 19, page 53-54 of the TS-0 Manual and manipulate the vertical attenuator switch through all of its positions. The display in figure 33 does not change. A d-c voltage, applied to E102, also does not produce any change in figure 33.

You have certainly verified the trouble symptom. By operating the vertical gain control through its limits for each position of the vertical attenuator switch, you also will have completed step 2—symptom elaboration. This is true because the vertical attenuator and vertical gain controls are the only operational controls associated with the symptom. All of these manipulations produce no change in figure 33.

Now that you have performed step 2—symptom elaboration—what is the next step?

SELECTIONS:

A. Localizing trouble to the circuit. (Page 30)

B. Listing of probable faulty functions. (Page 36)

C. Localizing the faulty function (Page 35)

from page 24

YOUR SELECTION:

A. The trouble is in the vertical amplifier.

Correct. The test results show that all outputs of the vertical amplifier are nonexistent. The fact that the TS-O screen has a horizontal trace indicates that the horizontal amplifiers are operating correctly. If the trouble were in the power supply, the horizontal as well as the vertical amplifier would be affected.

The vertical amplifier circuit group can now be bracketed. You should recall that the trouble was checked with inputs applied to the d-c as well as the a-c vertical input terminals. Opening brackets should be placed at these two points. All three outputs (test points 1, 2, and F) are bad; therefore, closing brackets should be placed at these points.

Paragraph d, page 14, of the TS-O manual explains the operation of each major circuit in the vertical amplifier. Study this information carefully, referring to the detailed block diagram on page 31-32.

Consult the servicing block diagram on page 53-54 of the TS-O manual. Which test point is the most logical point at which to make the next test?

SELECTIONS:

A. Test point B. (Page 23)

B. Test point C. (Page 31)

C. Test point D. (Page 16)

from page 25

YOUR SELECTION:

B. Vertical attenuator or vertical gain circuits.

Yes. The check at test point C eliminates the input paths of the switching circuit, and indicates that the trouble occurs before test point C.

If you arrived at this answer without first selecting the wrong circuit groups and without selecting the incorrect test points, you are applying step 5 of the trouble-shooting procedure correctly. However, if you took one or more devious routes, you should now appreciate the importance of utilizing the information and test results logically to prevent wasting time in making unnecessary tests.

Since the servicing block diagram does not show coupling circuits, you should refer to the TS-0 schematic on page 51-52 of the manual. After studying the switching paths in the vertical amplifier, which of the following is most likely to be at fault?

SELECTIONS:

A. Vertical gain control. (Page 38)

B. Vertical attenuator. (Page 22)

from page 27

YOUR SELECTION:

A. Localizing trouble to the circuit.

Good. Since the TS-0 is a single-unit equipment, you can skip steps 3 and 4 and go to step 5—localizing trouble to the circuit.

Paragraph 1, page 11, of the manual gives a complete description of the function of each circuit group in the TS-0. Study this information carefully, and then select the list of circuit groups which may be at fault in view of the information you have collected.

SELECTIONS:

A. Horizontal amplifier. (Page 40)

B. Vertical amplifier and power supply. (Page 24)

C. Cathode-ray tube. (Page 15)

from page 28

YOUR SELECTION:

B. Test point C.

The waveform obtained at this test point is shown in figure 37.

Compare the waveform obtained in this test with the one shown in the servicing block diagram, page 53-54 of the manual.

The location of the trouble is given in one of the following selections.

SELECTIONS:

A. Between the input of the vertical amplifier and test point C. (Page 25)

B. Between test point C and the output of the vertical amplifier. (Page 18)

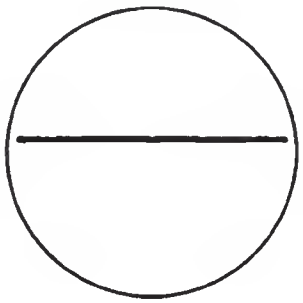

Figure 37. Waveform Obtained at Test Point C

from page 43

YOUR SELECTION:

C. Not in the switch.

No. The trouble is definitely in the switch. In this test the ohmmeter should show continuity when the switch is in any of the AC positions.

Read page 43 again and select another answer.

from page 40

YOUR SELECTION:

B. The trouble is in the power supply.

No. Although the test results indicate that the trouble is definitely not in the horizontal amplifier, the trouble cannot be isolated to the power supply because you did not select the correct list of circuit groups. The proper operation of the horizontal amplifier requires that the power supply is operating correctly; therefore, the test results tend to eliminate the power supply as a possible faulty circuit group. The horizontal trace shown in figure 33, page 26, should have indicated to you that the horizontal amplifier was operating correctly. Thus a test of this circuit group was unnecessary.

Reread page 30 and select a more logical answer.

from page 12

YOUR SELECTION:

C. Remove the set from the case and connect a signal to the vertical amplifier.

Definately not. The set should never be removed from its case until the symptoms are verified and elaborated upon. Always make sure you know what is meant by trouble symptoms before tearing into the set. Considerable time could be wasted if you tore the set apart only to find that someone previously had neglected to turn on the power switch.

Reread pages 11 and 12 then select a more appropriate answer.

from page 27

YOUR SELECTION:

C. Localizing the faulty function

No. Usually a single unit equipment performs only one function. You should have recalled that on a single unit equipment, steps 3 and 4 could be omitted.

Reread the information on page 27 and make a more logical choice.

from page 27

YOUR SELECTION:

B. Listing of probable faulty functions.

No. Look at the functional block diagram of figure 6, page 31-32, of the TS-O manual. How many functional units are shown? It is obvious that there is only <u>one</u>. There are six circuit groups, but the equipment consists of a single functional <u>unit</u>. For this reason you can skip steps 3 and 4 and proceed directly to step 5.

Reread page 27 and select a more logical answer.

from page 22

YOUR SELECTION:

B. Voltage check.

Such a check is satisfactory for isolating a faulty circuit branch; however, it does not readily apply to switches. A faulty switch is usually either shorted or open. Therefore, a resistance check is more feasible.

Return to page 22 and make a more logical choice.

from page 29

YOUR SELECTION:

A. Vertical gain control.

No. Although there is only one vertical gain control, it consists of two potentiometers ganged together, and it is not likely that both potentiometers are faulty.

Return to page 29 and select the correct answer.

from page 43

YOUR SELECTION:

A. Shorted switch contacts.

No. Shorted switch contacts would give a zero or near zero reading on the ohmmeter. A high reading would be normal with the switch in the AC-1, AC-10, and AC-100 positions. A shorted switch would also have continuity on other than the correct positions.

Read page 43 again and select another answer.

from page 30

YOUR SELECTION:

A. Horizontal amplifier.

To check the operation of the horizontal amplifier with the horizontal selector at the SWEEP position, another oscilloscope can be connected to the output test points of this circuit group. Figure 34 shows the waveforms obtained at these test points.

Compare the waveforms in figure 34 with those on the servicing block diagram, page 53-54, of the TS-0 manual. Considering these test results, which statement do you believe is correct?

SELECTION:

A. The trouble is in the horizontal amplifier. (Page 17)

B. The trouble is in the power supply. (Page 33)

C. The trouble is in neither the horizontal amplifier nor the power supply. (Page 19)

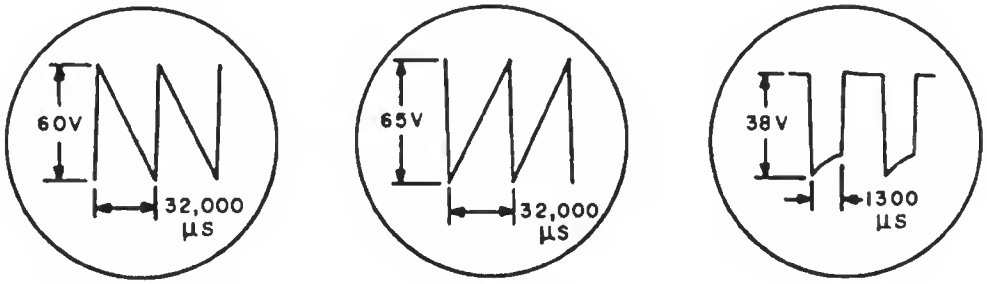

Figure 34. Output Waveforms for Horizontal Amplifier

from page 23

YOUR SELECTION:

B. Between test point B and the output of the vertical amplifier.

Yes. Your choice is correct because the signal is satisfactory, indicating that the trouble has to be beyond this test point.

However, this test eliminated only the cathode follower and one section of the vertical attenuator. You make an error in judgement earlier when you selected test point B for your first check. You should have selected the test point which would have eliminated the maximum number of circuits.

Reread page 28 and select a more logical answer.

from page 24

YOUR SELECTION:

C. The trouble is in neither the vertical amplifier nor the power supply.

Wrong. Tests show that there is no output from the vertical amplifier; therefore, this circuit group should be suspected as being faulty. The horizontal amplifier is providing a sweep and since its proper operation requires the same power supply as the vertical amplifier, the power supply would not be suspected.

Reread page 24 and select a more logical answer.

from page 22

YOUR SELECTION:

A. Resistance check.

Yes. A switch is normally tested by making a continuity check of the contacts. In other words, you should check the resistance from the input to the output of S101. This is done by placing the ohmmeter across the switch, as shown in figure 38. In this example, the ohmmeter reads infinity as the switch is moved through all positions.

This test result indicates that the trouble is one of the following selections.

SELECTIONS:

A. Shorted switch contacts. (Page 39)

B. Open switch contacts. (Page 44)

C. Not in the switch. (Page 32)

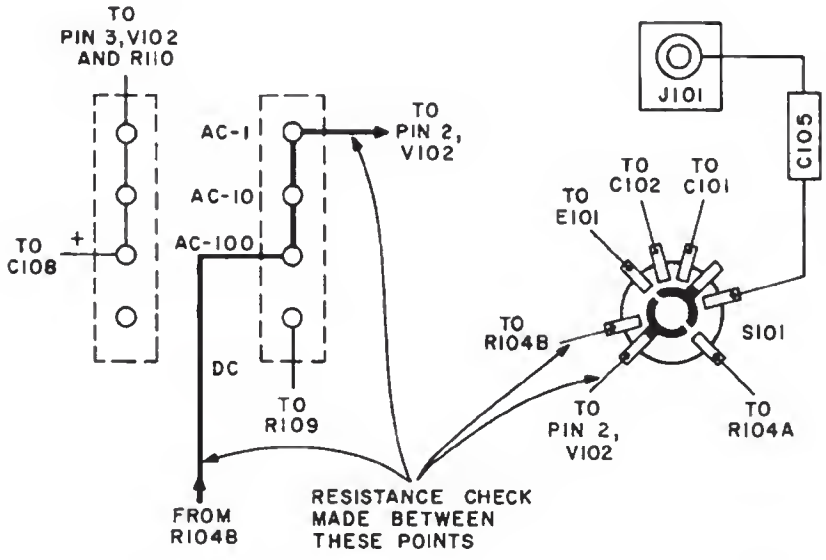

Figure 38. Resistance Check of Final Output Portion, S101

from page 43

YOUR SELECTION:

B. Open switch contacts.

Yes. An infinite ohmmeter reading indicates that there is an open connection in the switch, which would prevent the vertical signal from reaching the first d-c amplifier. This would result in the "no vertical deflection" symptom; therefore, it is a logical cause of the trouble.

This trouble can be caused by mishandling, wear, or oxidized or dirty contacts. A visual inspection should determine what repairs are necessary. A broken switch, of course, will have to be replaced. If the contact is merely bent or dirty, it can be repaired by adjusting or cleaning, as required.

Remember that the operation of the TS-0 should be checked after any repairs to determine whether the trouble found is the only trouble; then the Electronic Equipment Failure/ Replacement Report form can be filled out.

Turn to page 47 and begin lesson 3.

from page 22

YOUR SELECTION:

C. Signal injection.

No. Signal injection is used to isolate a defective circuit, but once it has been located, resistance and voltage checks must be used to further isolate the defective part.

Reread page 22 and select a more logical answer.

from page 62

LESSON NO. 3

TROUBLE-SHOOTING PROJECT NO. 2

You are trouble-shooting the modulator unit of Radar Set AN/XXX-1 (figure 18, fold-out page 5 of Vol. 1). Viewing the trigger oscillator output (test point 1) on the TS-0, you see the waveform shown in part A of figure 39. The TS-0 is operating on external sync. You are about to declare the trigger oscillator okay when the TS-0 display changes to that shown in part B. What has happened?

SELECTIONS:

A. There has been a malfunction in the TS-0. (Page 65)

B. There has been a malfunction in the trigger section of the radar set. (Page 58)

C. There is no way of knowing what has happened without further tests. (Page 53)

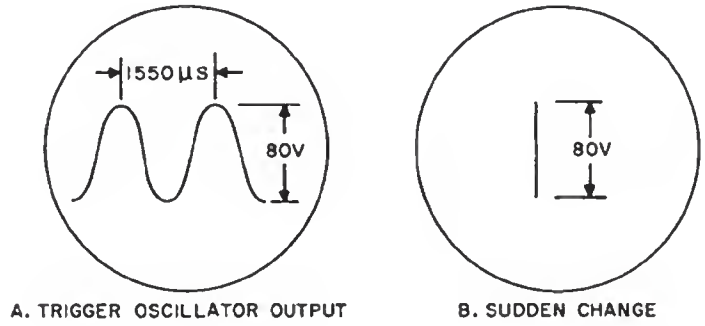

Figure 39. TS-0 Displays

from page 57

YOUR SELECTION:

C. None of the parts in the cathode circuit.

Wrong. It should be obvious from the resistance measurements that the cathode reading was much different from the value shown in the TS-O manual, and only a fault in the cathode circuit could cause this large deviation.

Read page 57 again and make a better selection.

from page 62

YOUR SELECTION

B. The trouble is in the horizontal amplifier.

This conclusion should be verified by checking the input and output waveforms for this circuit group. Refer to figure 19, page 53-54 of the TS-O manual. With the horizontal attenuator in the SWEEP position the input and output waveforms of the horizontal amplifier are shown in figure 42.

Considering these test results, which statement is true?

SELECTIONS:

A. The trouble is definitely in the horizontal amplifier
(Page 54)

B. The trouble is not in the horizontal amplifier.
(Page 74)

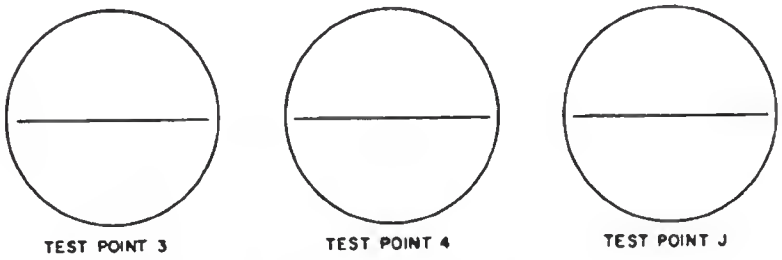

Figure 42. Test Waveforms for Horizontal Amplifier

from page 70

YOUR SELECTION:

B. Grid circuits (pins 5 and 6).

The resistance measurements from these pins to ground are slightly higher than the values shown in the TS-O manual. Study the sweep oscillator circuit on the schematic, figure 18, pages 51-52, of the TS-O manual.

Which part is probably faulty?

SELECTIONS:

A. R160. (Page 77)

B. R163. (Page 68)

C. None of the parts in the grid circuits. (Page 60)

from page 65

YOUR SELECTION:

A. Coarse frequency, vernier frequency, sync selector, and locking controls.

The coarse frequency control should be tried in each position as the vernier frequency control is varied. In this case the result remains the same—no sweep. The sync selector can also be checked in each position as the locking control is varied. There is again no change on the screen.

From these results, what should be your next step?

SELECTIONS:

A. Check other controls which might provide further elaboration of the trouble symptoms. (Page 69)

B. Select a list of probable faulty circuit groups. (Page 56)

from page 67

YOUR SELECTION:

B. Check the plate (pin 2) circuit.

No. Although the voltage measured at this point is far from normal, it is not the only section of the tube with incorrect voltage. This high plate voltage indicates that the plate current in the tube is near zero.

Read page 66 again and select another answer.

from page 47

YOUR SELECTION:

C. There is no way of knowing what has happened without further tests.

No. There is a definite clue as to which set has failed. Remember that the horizontal trace is provided by the sweep oscillator in the TS-0, and that the vertical trace represents the input signal from the radar set.

Read page 47 again and select another answer.

from page 49

YOUR SELECTION:

A. The trouble is definitely in the horizontal amplifier.

Absolutely not! You not only selected the wrong circuit group, but also analyzed the test results incorrectly. It should be obvious that with the input signal missing the trouble must be ahead of this circuit group. In the last symptom elaboration step, the line test signal was applied to both horizontal and vertical inputs, and the results were the same as shown in figure 3D, page 6, of the TS-0 manual. This step indicated that the horizontal amplifier is operating normally, and a test of this circuit group was unnecessary.

Read page 62 again and make the correct selection.

from page 73

YOUR SELECTION:

A. R156.

No. The resistance at pin 2 consists of the plate load resistor (R156) plus the resistance of the medium-voltage power supply, which can easily vary as much as the difference in the measured value and the value in the TS-0 manual. The trouble in this example is the complete failure of the sweep oscillator, and could not be caused by a small change of resistance. You should not have selected the plate circuits as the source of trouble in the sweep oscillator.

Read page 70 again and select a better answer.

from page 51

YOUR SELECTION:

B. Select a list of probable faulty circuits groups.

No. You selected the wrong group of controls for the symptom elaboration. The sync selector and locking control are not located in circuits which could prevent a trace on the scope. When these controls were manipulated with no resulting change on the screen, you should have checked the possibility that there might be other controls which were more likely to provide additional information before going to the next step. You did not satisfactorily complete step 2 before you went on to step 3.

Reread page 65 and select a more logical answer.

from page 70

YOUR SELECTION:

A. Cathode circuit (pin 7).

The resistance measured at this pin is higher than the value shown in the TS-O manual. Study the sweep oscillator schematic in figure 18, page 51-52, of the TS-O manual.

Which part is probably faulty?

SELECTIONS:

A. Internal blanking strip on rear terminal board (open). (Page 71)

B. R161. (Page 59)

C. None of the parts in the cathode circuit. (Page 48)

from page 47

YOUR SELECTION:

B. There has been a malfunction in the trigger section of the radar set.

No. There is still a vertical deflection on the TS-O screen, which indicates that there is still an 80-volt signal applied to the vertical section of the TS-O. A malfunction in the trigger circuit would probably have an effect on the amplitude of the trigger output.

Read page 47 again and select another answer.

from page 57

YOUR SELECTION:

B. R161.

Yes. This is a 470-ohm resistor between cathode and ground. To make certain that the trouble is a faulty resistor rather than a broken connection or bad solder joint, you should make a resistance check directly across the resistor leads. In this example the reading is the same (1 megohm). R161 is definitely defective; however, if it were open, its resistance should be infinity. How can you explain the fact that you measure a resistance of 1 megohm from pin 7 of V108 to ground?

SELECTIONS:

A. The cathode resistor increased its resistance to a very high value, but did not open completely. (Page 75)

B. The 1-megohm reading is the cathode-to-grid resistance of V108 in series with R163. (Page 63)

C. The 1-megohm reading represents the resistance of R164 in the intensity modulation amplifier. (Page 78)

from page 50

YOUR SELECTION:

C. None of the parts in the grid circuits.

True. The resistance measurements were only 20% higher than the values shown in the TS-O manual. This is not unusual since most resistors have a 20% tolerance. You should not have selected the grid circuits as the source of trouble in the sweep oscillator circuit.

Reread page 70 again and select a better answer.

from page 67

YOUR SELECTION:

A. Check the grid (pin 6) circuit.

No. There is no reason to suspect this part of the sweep oscillator more than the other sections of the tube. If the circuit were not oscillating, there would not be any d-c voltage applied to the grid.

Read page 66 again and select another answer.

from page 65

YOUR SELECTION:

B. Coarse frequency, vernier frequency, horizontal attenuator, and horizontal gain controls.

The coarse frequency control should be tried in each position as the vernier frequency control is varied. In this case the result remains the same--no sweep. To properly check the horizontal attenuator, an external signal should be applied to the a-c and d-c horizontal input terminals. Although this would appear to be part of step 5, the output jack located on the front panel can be used to further elaborate the symptom without the use of other test equipment. By connecting the line test jack to both the vertical and horizontal a-c input terminals and switching the horizontal attenuator to the AC-10 position, a pattern is obtained on the TS-O screen as shown in figure 41. The horizontal gain control works normally.

From this additional information, which conclusion is most valid?

SELECTIONS:

A. The trouble is in the sweep oscillator. (Page 66)

B. The trouble is in the horizontal amplifier. (Page 49)

C. There is not sufficient data to isolate the faulty circuit group. (Page 72)

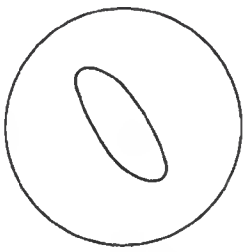

Figure 41. TS-O Pattern with Line Test Terminal Connected to Both Horizontal and Vertical A-C Inputs

from page 59

YOUR SELECTION:

B. The 1-megohm reading is the cathode-to-grid resistance of V108 in series with R163.

No. The resistance from cathode to grid should be infinity in a good tube, and remember that the original tube was replaced with a good one. There is a more logical explanation for the 1-megohm reading.

Read page 59 again and make the correct selection.

from page 73

YOUR SELECTION:

B. R157.

No. The resistance at pin 1 consists of R157 and R158A plus the resistance of the medium-voltage power supply. R157 is only 330K, and is in series with a 5-megohm variable resistor. A small difference in the resistance value in this circuit would result in a change of oscillator frequency, but would not cause complete failure of the circuit. You should not have selected the plate circuits as the source of trouble in the sweep oscillator.

Read page 70 again and select a better answer.

from page 47

YOUR SELECTION:

A. There has been a malfunction in the TS-O.

Yes. There is good reason to believe that the trouble is in the TS-O. The horizontal trace disappeared; however, the vertical trace is the same amplitude as before the trouble occurred, which indicates that the trigger oscillator output is still present. Although the TS-O was operating with external synchronization, the loss of external sync signals would not cause the sweep to disappear (remember that it only stabilizes the pattern on the screen).

The TS-O presentation after the trouble occurred is repeated in figure 40.

Which operational controls should be manipulated to elaborate on the trouble symptom?

SELECTIONS:

A. Coarse frequency, vernier frequency, sync selector, and locking controls. (Page 51)

B. Coarse frequency, vernier frequency, horizontal attenuator, and horizontal gain controls. (Page 62)

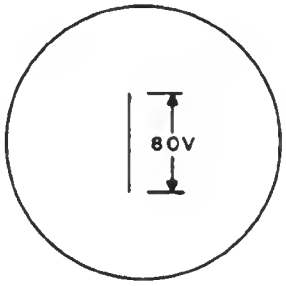

Figure 40. TS-O Display After Sudden Change Occurred

from page 62

YOUR SELECTION:

A. The trouble is in the sweep oscillator.

Yes. The symptom elaboration step proved that the horizontal trace was normal when the horizontal attenuator was in the AC-10 position, but there was no horizontal trace in the SWEEP position. This eliminates the horizontal amplifier as a trouble source, and, since the sweep oscillator obtains power from the same supply as the horizontal amplifier, the power supply should not be suspected. This is a good example of the importance of the symptom elaboration step—the trouble has essentially been isolated to a circuit group without making any internal tests of the TS-0.

This conclusion should be verified by placing the horizontal attenuator in the SWEEP position and checking the sweep oscillator output. The outputs of the sweep oscillator at test points J and K (figure 19, page 53-54 of the TS-0 manual) are shown in figure 43, page 67.

Since both outputs of this circuit group are nonexistent, output brackets should be placed at test points J and K to indicate faulty outputs. The input bracket is not necessary since the sweep oscillator circuit is a multivibrator and thus generates its own signal. The input signal is only for synchronization, and is not required for the operation of the sweep oscillator. There is only one circuit in the sweep oscillator circuit group; therefore, by bracketing this circuit, you have completed step 5 of the trouble-shooting procedure; now you should begin step 6—failure analysis.

This circuit group contains only one vacuum tube, and since vacuum tubes have a higher failure rate than other parts, checking or replacing V108 would be an appropriate procedure at this time. However, you replace the 6J6 tube and the trouble remains.

The next step is to make voltage measurements at the tube pins. These values are shown in figure 44, page 67 Compare them with the values given in figure 17, page 49-50, of the TS-0 manual. The voltages are not shown for pins 3 and 4, which are the filaments. A technician normally does not measure filament voltages unless there is an indication of filament trouble. The filaments of glass tubes can be checked

(continued on the next page)

from page 66

visually, and of metal tubes by touch. Study the detailed analysis of the sweep oscillator on page 16 of the TS-O manual.

What should you do next?

SELECTIONS:

A. Check the grid (pin 6) circuit. (Page 61)

B. Check the plate (Pin 2) circuit. (Page 52)

C. Take a resistance measurement at all pins. (Page 70)

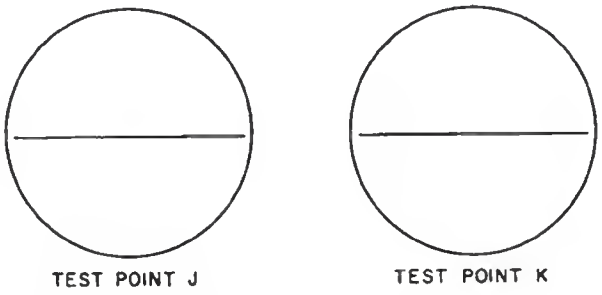

Figure 43. Test Waveforms for Sweep Oscillator

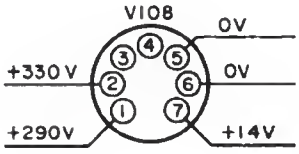

Figure 44. Voltage Check of V108

from page 50

YOUR SELECTION:

B. R163.

No. This resistor is the grid return for one half of the oscillator circuit, and also serves as part of a voltage divider for the sync signal. The difference in the measured value of resistance across this resistor would not cause any noticeable effect on the operation of the oscillator. The grid circuits were a poor choice.

Read page 70 again and select a better answer.

from page 51

YOUR SELECTION:

A. Check other controls which might provide further elaboration of the trouble symptoms.

Yes. You did not select the correct list of controls for the symptom elaboration step. The sync selector and locking controls are not located in circuits which could prevent a trace on the scope. They affect only the stability of the displayed waveform. You did not complete step 2 before you attempted to go on. This can result in a waste of time. Make sure your elaboration step is thorough before attempting to proceed.

Reread page 65 and make a more logical choice.

from page 67

YOUR SELECTION:

C. Take a resistance measurement at all pins.

Yes. Since there are several incorrect voltages at the tube, a resistance check at each pin should be made.

Figure 45 shows the resistance value measured at the pins of V108. Compare them with the values given in figure 17, page 49-50, of the TS-0 manual.

Which circuit or circuits of the tube now appear to be faulty?

SELECTIONS:

A. Cathode circuit (pin 7). (Page 57)

B. Grid circuits (pins 5 and 6). (Page 50)

C. Plate circuits (pins 1 and 2). (Page 73)

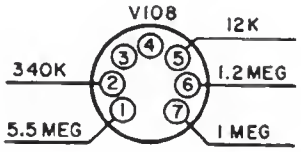

Figure 45. Resistance Check of V108

from page 57

YOUR SELECTION:

A. Internal blanking strip on rear terminal board (open).

No. This strip is connected when it is desired to blank the retrace on the screen. If this strip were broken or removed, the TS-0 would function normally except that the retrace would be visible.

Read page 57 again and select a better answer.

from page 62

YOUR SELECTION:

C. There is not sufficient data to isolate the faulty circuit group.

Wrong. The results of the symptom elaboration step definitely point to one circuit group as the trouble area. You have overlooked an important point. The horizontal attenuator's position should be a clue.

Read page 62 again and compare the pattern shown in figure 41, page 62 of the text with the figure 3D, page 6, of the TS-O manual. Then select a more logical choice.

from page 70

YOUR SELECTION:

C. Plate circuits (pins 1 and 2).

The resistance measured at pin 1 is lower and at pin 2 higher than the values in the TS-O manual. Study the sweep oscillator schematic in figure 18, page 51-52, of the TS-O manual.

Which part is probably faulty?

SELECTIONS:

A. R156. (Page 55)

B. R157. (Page 64)

C. None of the parts in the plate circuits. (Page 76)

from page 49

YOUR SELECTION:

B. The trouble is not in the horizontal amplifier.

Correct. The test results show that the trouble is in a circuit group ahead of the horizontal amplifier. However, you should have realized this sooner. In the last symptom elaboration step, the line test signal was applied to both horizontal and vertical inputs and the results were the same as shown in figure 3D, page 6, of the TS-O manual. This step indicated that the horizontal amplifier is operating normally, and a test of this circuit group was unnecessary.

By now you should realize that you will not always be stopped if you start down the wrong branch. Consider each symptom carefully before proceeding.

Reread page 62 and make a more logical choice.

from page 59

YOUR SELECTION:

A. The cathode resistor increased its resistance to a very high value, but did not open completely.

No. A resistor seldom increases 2000 times its original value without opening completely, although this is possible. However, there is a much more logical reason for the 1-megohm resistance reading.

Read page 59 again and make another selection.

from page 73

YOUR SELECTION:

C. None of the parts in the plate circuits.

True. Although the voltage readings at the plates were far from being correct, the resistance readings were only slightly different from the correct values. Since the trouble is the complete failure of the sweep oscillator, you should not have selected the plate circuits as the source of the trouble.

Read page 70 again and select a better answer.

from page 50

YOUR SELECTION:

A. R160.

No. It is true that R160 could have increased in value; however, this would not prevent the oscillator from operating. The resistance measurement at the grid was 1.2 megohms, only 20% higher than the value in the TS-0 manual (1 megohm). Besides, there is a 1-megohm potentiometer connected as a variable resistor in the circuit which is part of the vernier frequency control. If the resistance changed in this circuit, it would only result in a change of the oscillator frequency. The grid circuits were a poor choice.

Read page 70 again and select a better answer.

from page 59

YOUR SELECTION:

C. The 1-megohm reading represents the resistance of R164 in the intensity modulation amplifier.

Yes. If you trace the lead from the cathode of V108 to the internal blanking strip on the rear terminal load, you will find that it connects to the grid of V105B, which has a 1-megohm resistor from grid to ground. By removing the shorting strip on the terminal load at the rear of the TS-0, internal blanking is removed, and the resistance measurement at the cathode of V108 would then be infinity.

The test results can now be explained. The cathode resistor opened, leaving a 1-megohm resistor in place of the 470-ohm bias resistor. This large resistor allowed a current of only a few microamperes to flow through the tube, resulting in the high plate voltages, which accounts for the high positive voltage at the cathode. The tube, when operating so near cutoff, could not operate as a multivibrator.

R161 could have burned open because of a fault in construction or because of a heavy surge of current. By checking the original tube, you can determine whether the trouble was originally due to a faulty tube. The resistor should be replaced and the TS-0 checked again to make certain that it is operating properly before filling out the Electronic Equipment Failure/Replacement Report.

Go to page 79 and begin Lesson 4.

from page 78

LESSON 4

TROUBLE-SHOOTING PROJECT NO. 3

Assume that you are going to observe the output waveform from the modulator section of a transceiver set with the TS-O. Plug the power cord of the TS-O into the power socket, and turn the intensity control clockwise so that it "clicks" and the pilot lamp is illuminated. While the oscilloscope is warming up, set the HORIZONTAL attenuator switch to the SWEEP position. You have not yet connected the signal from the modulator output to the vertical input posts. After a considerable warm-up period has passed, you check the TS-O screen and figure 46 is what you see.

From your knowledge of the operational function of the TS-O and the control settings indicated above, which of the following selections describes the condition which exists?

SELECTIONS:

A. There is no trouble symptom. (Page 86)

B. No horizontal trace is being produced. (Page 114)

C. There has been a complete failure on the part of the TS-O. (Page 90)

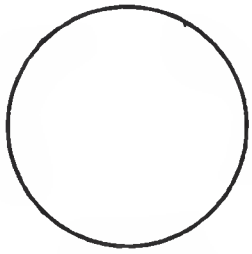

Figure 46. TS-O Display for Conditions Given in Text

from page 123

YOUR SELECTION:

B. Switching and divergent.

No. This is not quite true. The horizontal attenuator does not select one of three possible inputs -- sweep, external ac, and external dc. However, this circuit group contains not only a divergent path, but also a convergent-divergent path. The signal diverges at the output of the A section of the first d-c amplifier, and converges at the B section of the second d-c amplifier. One of these signal paths is a secondary signal path; however, it still must be considered a convergent path. There is another divergence at the output of V107A.

Read page 123 again and make another selection.

from page 99

YOUR SELECTION:

B. Sweep oscillator, cathode-ray tube, and power supply.

To check the output of the sweep oscillator, another oscilloscope must be used. The output waveforms for this circuit group are shown in figure 50.

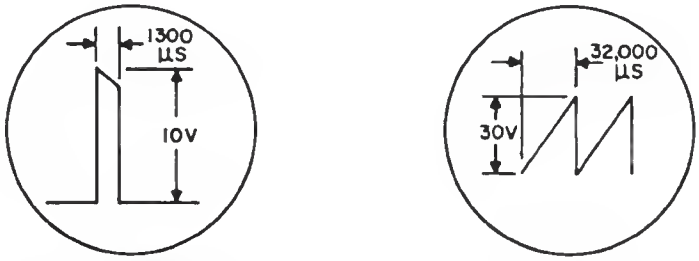

Figure 50. Sweep Oscillator Output Waveforms

The output of the cathode-ray tube is the visual pattern on the screen, which has been checked in steps 1 and 2. Therefore, no test is required to check the output of this circuit group.

The power supply can be checked by measuring the output voltages. The high voltage can be measured at R169, which is a convenient test point. In this case it reads -560 volts, which is correct. The low voltage is available at R170, and it is also correct (+107 volts). The medium voltage is not so easily accessible; however, it is used by the sweep oscillator, and the operation of this circuit group should be a definite indication of the operation of the medium voltage supply.

Considering the data obtained at this point, which of the following steps would be most appropriate?

SELECTIONS:

A. Select another group of possible faulty sub-functions. (Page 96)

B. Make additional checks of the power supply. (Page 132)

C. Check all inputs to the cathode-ray tube. (Page 113)

from page 139

YOUR SELECTION:

C. There is not sufficient information to determine the faulty circuit.

Correct. This means that you selected the wrong test point. Test point P is in a secondary signal path which carries only the high-frequency components of the horizontal signal. Although this signal is normal for a low-frequency signal, and should be an indication that the first d-c amplifier is operating satisfactorily, primary signal paths should be checked first.

Read page 120 again and select the test point in the primary signal path.

from page 114

YOUR SELECTION:

A. Intensity, focus, positioning, horizontal attenuator, horizontal gain, and coarse and vernier frequency controls.

Yes. Once the intensity control has been switched to the "on" position, further rotation varies the intensity of the cathode-ray-tube electron beam, thereby varying the brightness of the trace on the screen. In this case its manipulation produces no change on the screen.

The horizontal gain control determines the horizontal width of the display on the screen. Its manipulation, in this case, produces no effect.

The coarse and vernier frequency controls determine the rate at which the spot sweeps across the screen in the horizontal direction. Again, there is no change on the screen as these controls are adjusted.

The positioning controls could be adjusted so that the trace is "off the screen". However, no trace appears despite their manipulation.

Moving the horizontal attenuator control away from the SWEEP position removes the sawtooth sweep signal from the cathode-ray-tube horizontal deflection plates. The horizontal sweep would normally appear as a spot on the CRT when this is done; however, the screen still appears as shown in figure 47, fold-out page 12.

Finally, manipulation of the focus control produces no change on the screen.

In view of the data above, what conclusion must you reach?

SELECTIONS:

A. I have gained no additional information which would help me elaborate on the original symptom. (Page 126)

B. There is no spot on the TS-0 screen. (Page 98)

C. I must manipulate some of the other operating controls and try to gain more information. (Page 110)

from page 119

YOUR SELECTION:

B. Cathode-ray tube.

No. The inputs to this circuit group have been checked. If you will review the test results, it should be obvious that not all of these inputs are correct. Therefore, the trouble must be in another circuit group.

Read page 119 and make another selection.

from page 87

YOUR SELECTION:

A. The trouble is between the input of this circuit group and test point N.

No. The waveforms at test point N is almost identical to the one shown in the servicing diagram. This means that all the circuits between the input and test point N are performing satisfactorily and the trouble cannot be in the circuits you selected.

Return to page 87 and select the correct answer.

from page 79

YOUR SELECTION:

A. There is no trouble symptom.

In order to aid you in studying this lesson, the original TS-0 display and the initial control settings and indications are given in figure 47, fold-out page 12. You can refer to this information as often as you need it.

Now apply the signal from the modulator output (transceiver set) to the vertical input posts, and set the vertical attenuator switch to the AC-10 position. Figure 48 shows the TS-0 screen.

Which selection below describes the present condition of the oscilloscope?

SELECTIONS:

A. There is no waveform display on the TS-0 screen. (Page 130)

B. There is no visible indication that the TS-0 is operating. (Page 122)

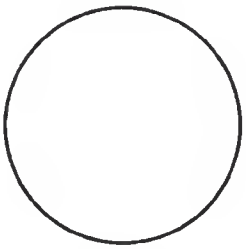

Figure 48. TS-0 Display With Vertical Signal Applied

from page 116

YOUR SELECTION:

A. Test point N.

The oscilloscope waveform viewed at this test point is shown in figure 55.

From this information what conclusion do you draw?

SELECTIONS:

A. The trouble is between the input of this circuit group and test point N. (Page 85)

B. The trouble is between test point N and the output of this circuit group. (Page 120)

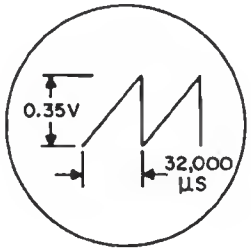

Figure 55. Waveform at Test Point N

from page 103

YOUR SELECTION:

A. I have gained no additional information.

This is not quite true. You have established that the horizontal gain control which controls the width of the sweep does not have any effect. However, your selection of controls was incorrect because the vertical selector and vertical gain controls are used to control the size of the vertical signal, and with no signals applied there is no reason to adjust them.

Restudy the purpose of the TS-0 controls on page 3 of the TS-0 manual. Then return to page 114 of this lesson and select the proper answer.

from page 112

YOUR SELECTION:

A. R145.

No. This resistor is in the plate 1 circuit, which measured almost the same resistance as shown in the service manual. The reading obtained at the other plate, however, indicates that there is definitely something wrong.

Read page 112 again and select the faulty part.

from page 79

YOUR SELECTION:

C. There has been a complete failure on the part of the TS-O.

No. The fact that the pilot lamp is illuminated shows that the TS-O has not failed completely. However, you are correct in realizing that some trouble indication does exist.

Return to page 79 and study the settings of the TS-O. Then make a better choice.

from page 107

YOUR SELECTION:

B. R144.

No. The resistance between pin 5 and ground is normally 80K, and the measured value is only 5K higher. This is not excessive because most of the grid circuit resistance is in the power supply. You should never have selected the grid circuits as being at fault, since the voltage was closer to normal than in the other tube sections.

Read page 124 again and make another selection.

from page 120

YOUR SELECTION:

C. I am ready to go to step 6—failure analysis.

No. The fault is located in either the first or second d-c amplifiers. There are too many components involved in these circuits to begin failure analysis. The trouble should first be isolated to a single stage.

Read page 120 again and select the proper test point.

from page 133

YOUR SELECTION:

C. None of the parts in the cathode circuit.

Correct. The small difference between the normal cathode resistance and the measured value can be caused by the variable resistor in the cathode circuit. However, you should have selected the tube section with the greatest deviation of voltage from the normal value. The low cathode voltage would be the result of decreased plate current, which could be caused by a fault in another section of the tube.

Read page 124 again and make another selection.

from page 116

YOUR SELECTION:

B. Test point M.

The oscilloscope waveform obtained at this test point is shown in figure 53.

Considering this information, which conclusion is most valid?

SELECTIONS:

A. The trouble is located between the input of this circuit group and test point M. (Page 102)

B. The trouble is located between test point M and the output of this circuit group. (Page 121)

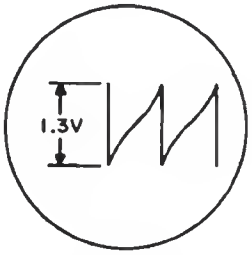

Figure 53. Waveform at Test Point M

from page 114

YOUR SELECTION:

C. Sync selector, locking, and coarse and vernier frequency controls.

No. There is no reason to operate the sync selector and locking controls. These controls are used to stabilize the waveform on the screen, and their operation could add no information concerning this problem.

Read page 114 again and make another selection.

from page 81

YOUR SELECTION:

A. Select another group of possible faulty sub-functions.

Yes. Although you have not completely eliminated the group of sub-functions selected, you may re-evaluate the data obtained at this point. You did not use the logical approach when you selected the sweep oscillator, cathode-ray tube, and power supply. This group did not include every possible faulty circuit group, and it included at least one which is not a likely course of the trouble. Be sure to analyze each selection to make sure that a fault in the circuit group of your choice could result in the symptoms given.

Reread page 99 and select a more logical answer.

from page 133

YOUR SELECTION:

B. R142.

No. There is a variable resistor in series with R142 which can easily explain the 1K difference between the measured and normal cathode resistance. Although the cathode voltage was low, it was not the tube section with the greatest deviation from normal. The low cathode voltage would be a result of decreased plate current, which could be caused by a fault in another section of the tube.

Read page 124 again and make another selection.

from page 83

YOUR SELECTION:

B. There is no spot on the TS-O screen.

This conclusion completes the symptom elaboration step in the six-step procedure. Although the trouble seemed to be a lack of horizontal trace, your conclusion was reached because the deflection voltage was removed from the horizontal plates when the horizontal attenuator control was moved from the SWEEP position. With no horizontal or vertical deflection voltage, there should be a stationary spot on the TS-O screen. Since no amount of adjusting of the intensity, focus, and positioning controls provides a spot, you must assume that it is not there.

The complete elaboration data is listed below:

1. Intensity - no change.
2. Focus - no change.
3. Positioning (vertical and horizontal) - no change.
4. Horizontal attenuator - no change.
5. Horizontal gain - no change.
6. Frequency (coarse and vernier) - no change.

At this point, the logical thing to do is to review all the data you have accumulated, and analyze the problem. According to the information, there is no spot or trace on the TS-O screen, regardless of control manipulations. To analyze this problem, you should consider the possible causes of this symptom. It should be obvious that either there is no electron beam inside the CRT, or, if one does exist, it is not reaching the screen. (Another possibility is a completely burned-out coating on the screen; however, this would be eliminated.) You should keep in mind, then, that the trouble is in a circuit group which can cause one of the two existing possible conditions.

(continued on the next page)

Normally, the next procedure in step 5 is to bracket the good inputs and bad outputs of the defective functional unit. In this case, however, the problem exists without any input signals applied, and the output of the unit is the visual indication on the CRT. To begin the bracketing of the unit, you should place an output bracket (mentally) at the CRT screen.

Page 11, paragraph 1, of the TS-O manual gives a complete description of the function of each circuit group in the TS-O. Study this information carefully, and then select the group of subfunctions which may be at fault in view of the information you have obtained.

Figure 18 and 19 pages 51-52 and 53-54 respectively, should be consulted throughout the remainder of this lesson. All waveforms should be compared with those in figure 19.

SELECTIONS:

A. Horizontal amplifier, vertical amplifier, power supply, and cathode-ray tube. (Page 119)

B. Sweep oscillator, cathode-ray tube, and power supply. (Page 81)

C. Vertical amplifier, synchronization, cathode-ray tube, and power supply. (Page 137)

from page 120

YOUR SELECTION:

B. Test point O.

The oscilloscope waveform viewed at this test point is shown in figure 57.

Considering this test result, which circuit is faulty?

SELECTIONS:

A. First d-c amplifier, V106A and B. (Page 109)

B. Second d-c amplifier, V107A and B. (Page 124)

C. There is not sufficient information to determine the faulty circuit. (Page 138)

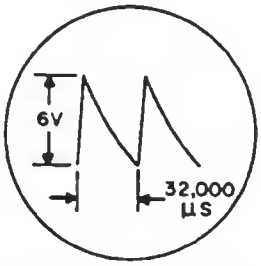

Figure 57. Waveform at Test Point O

from page 107

YOUR SELECTION:

C. None of the parts in the grid circuits.

Correct. The resistance measurements are almost the same as those shown in the servicing block diagram. However, you should have noticed that the grid voltages were also very close to normal before selecting the grid circuits as faulty.

Read page 124 again and make another selection.

from page 94

YOUR SELECTION:

A. The trouble is located between the input of this circuit group and test point M.

No. The waveform at test point M is almost identical to the one shown in the servicing diagram. It should have been obvious that the trouble is beyond this point.

You made a poor choice when selecting test point M for the first check within this circuit group. Only the cathode follower and part of the horizontal attenuator can be eliminated by this test.

Read page 116 again and select another test point.

from page 114

YOUR SELECTION:

B. Vertical attenuator, horizontal attenuator, vertical and horizontal gain, and coarse and vernier frequency controls.

The vertical attenuator control determines how much of the signal applied to the vertical input posts will be applied to the vertical amplifiers. The horizontal attenuator control determines how much of the signal applied to the horizontal input posts will be applied to the horizontal amplifiers, or how much of the signal from the sweep oscillator will be applied to the horizontal amplifiers. In this case manipulation of both these controls produces no effect on the TS-0 display.

The vertical gain control adjusts the degree of amplification for the vertical amplifiers, and the horizontal gain control adjusts the degree of amplification for the horizontal amplifiers, thereby adjusting the horizontal width of the display on the TS-0 screen. In this case the adjustments have no effect.

The coarse and vernier frequency controls select the range of frequencies of the internal sweep circuit oscillator. These controls have no effect on the TS-0 screen.

In view of the discussion above, what conclusion do you reach?

SELECTIONS:

A. I have gained no additional information. (Page 88)

B. There was no reason to manipulate the vertical selector and vertical gain controls. (Page 117)

C. I should proceed to formulate a faulty unit selection with the information I have. (Page 135)

from page 112

YOUR SELECTION:

C. R185.

No. Although this resistor is in the plate 2 circuit, it is normally shorted out except when the horizontal input is applied directly to the CRT. If R185 were open and the shorting strip were removed, it could cause the original trouble symptoms; however, it would not cause the incorrect voltage and resistance measurements at V107.

Return to page 112 and select the faulty part.

from page 139

YOUR SELECTION:

A. First d-c amplifier, V106A and B.

The faulty circuit cannot be determined by the check at test point P. This test point is in a secondary signal path which carries only the high-frequency components of the horizontal signal. However, this signal is normal for the low-frequency signal, which should be an indication that the first d-c amplifier is operating satisfactorily.

Read page 120 again and select the test point in the primary signal path.

from page 137

YOUR SELECTION:

A. Vertical amplifier.

No. The vertical amplifier outputs are about 15% low, but you should realize that there are several stages and adjustments between the test signal and the output which can easily result in this difference. Besides, in this case it should be obvious from the original symptoms that something has failed completely, and it is not a matter of slightly below normal performance.

Your first mistake, however, was in selecting the group of possible faulty sub-functions. A faulty synchronization channel could not cause the observed symptoms.

Read page 99 again and make another selection.

from page 125

YOUR SELECTION:

A. Grid circuits (pins 5 and 6).

To check the grid circuits, a resistance measurement should be made at pins 5 and 6.

The resistance measurement at pin 5 is 85K, and at pin 6 is 87K.

Considering this information, which part has probably failed?

SELECTIONS:

A. R143. (Page 118)

B. R144. (Page 91)

C. None of the parts in the grid circuits. (Page 101)

from page 137

YOUR SELECTION:

C. None of these circuit groups are at fault.

Correct. The differences in amplitudes of the measured waveforms and the waveforms shown in the servicing block diagram are not unusual. The tolerances in resistor values and the gains of the vacuum tubes can easily result in these differences. Since the vertical amplifier and synchronization outputs are satisfactory, the power supply must also be operating properly.

You should realize by this time that you made an error in selecting a group of possible faulty sub-functions.

Read page 99 again and make another selection.

from page 100

YOUR SELECTION:

A. First d-c amplifier, V106A and B.

No. You should know after examining the waveform at test point O that the output of the A section of this circuit is satisfactory and the B section of this circuit is not in the primary signal path; therefore, this circuit should be eliminated as a possible trouble.

Return to page 100 and make another selection.

from page 83

YOUR SELECTION:

C. I must manipulate some of the other operating controls and try to gain more information.

You have manipulated the intensity, focus, positioning, horizontal attenuator, horizontal gain, and coarse and vernier frequency controls. Re-study paragraph 2, page 3, of the TS-0 manual. This should show you that these are the only controls associated with the original symptom, since we are not applying a vertical deflection voltage.

Return to page 83 and take a clear look at the data given for each control manipulation. Then make a better selection.

from page 131

YOUR SELECTION:

B. The trouble is in the second d-c amplifier.

Although the waveform shown resembles the one shown in the servicing block diagram, this signal is in a secondary path which represents only the high-frequency components of the horizontal signal. Therefore, the trouble cannot be definitely narrowed to this circuit. You should always select the test point which will eliminate or verify the maximum number of circuits.

Read page 116 again and select another test point.

from page 125

YOUR SELECTION:

B. Plate circuits (pins 1 and 2).

Yes. Both of these plates should read +250 volts. Something is definitely wrong when plate 1 reads +175 volts and plate 2 reads +0.37 volt. We can gather more information about the plate circuit between pins 1 and 2 by making a resistance check at each of the pin connections.

CAUTION

Resistance measurements are made with the equipment power cord unplugged. This insures that the ohmmeter will not be damaged.

The resistance measured from pin 1 to ground is 140K, and the ohmmeter reading at pin 2 is infinity.

Considering this information, which part is probably faulty?

SELECTIONS:

A. R145. (Page 89)

B. R146. (Page 140)

C. R185.(TB 105). (Page 104)

from page 81

YOUR SELECTION:

C. Check all inputs to the cathode-ray tube.

You have eliminated the power supply and the sweep-oscillator circuits. Your decision to test all inputs to the cathode-ray tube is a logical one, becuase the output of this section is definitely incorrect, and either this section is defective or one of the inputs is incorrect.

However, you should realize at this point that your selection of possible faulty sub-functions was not the most logical one, since it did not include all the circuit groups that have their output connected to the cathode-ray tube.

Return to page 99 and select the group which includes all sub-functions whose output is applied to the cathode-ray tube.

from page 79

YOUR SELECTION:

B. No horizontal trace is being produced.

Correct. In order to aid you in studying this lesson, the original TS-O display and the initial control settings and indications are given on fold-out page 12 at the end of this text. You can refer to this information as often as you like. With the a-c power on as indicated by the pilot lamp and with the horizontal attenuator switch in the SWEEP position, there should be a horizontal trace on the cathode-ray screen. Its absence indicates that either there is a malfunction somewhere in the TS-O, or there is a control incorrectly adjusted.

In order to obtain more information about the trouble symptom, which selection below lists the group of operational controls which should be manipulated?

SELECTIONS:

A. Intensity, focus, positioning, horizontal attenuator, horizontal gain, and coarse and vernier frequency controls. (Page 83)

B. Vertical attenuator, horizontal attenuator, vertical and horizontal gain, and coarse and vernier frequency controls. (Page 103)

C. Sync selector, locking, and coarse and vernier frequency controls. (Page 95)

from page 139

YOUR SELECTION:

B. Second d-c amplifier, V107A and B.

Not necessarily. The faulty circuit cannot be determined by the check at test point P. This test point is in a secondary signal path which carries only the high-frequency components of the horizontal signal. Although this signal is normal for a low-frequency signal and should be an indication that the first d-c amplifier is operating satisfactorily, primary signal paths should be checked first.

Read page 120 again and select the test point in the primary signal path.

from page 123

YOUR SELECTION:

C. Switching and convergent-divergent.

Yes. The horizontal attenuator does select one of three possible inputs--sweep, external ac, and external dc. The signal diverges at the output of V106A and V107A, and converges at V107B. One of the inputs to V107B is a secondary signal path. There is only a small signal in V106B when the sweep is a low-frequency signal (a sweep of 33,000 usec is equivalent to 30 cycles). There is also another signal path in this circuit group--the secondary path through the intensity modulation amplifier.

Paragraph 2C, page 12, of the TS-O manual explains the operation of each major circuit in the horizontal amplifier. Study this information carefully, referring to the servicing block diagram on page 53-54.

Consult the servicing block diagram, figure 19, page 53-54, of the TS-O manual. In view of your knowledge of bracketing techniques where should you perform the first test?

SELECTIONS:

A. Test point N. (Page 87)

B. Test point M. (Page 94)

C. Test point P. (Page 131)

from page 103

YOUR SELECTION:

B. There was no reason to manipulate the vertical selector and vertical gain controls.

True. These controls are associated with a signal applied to the vertical input posts of the TS-0. However, the original conditions occurred with no vertical signal applied.

Obviously, you must select a different group of controls if you expect to elaborate upon the symptom. Return to page 114 and make another selection.

from page 107

YOUR SELECTION:

A. R143.

No. The resistance between pin 6 and ground is normally 80K. The measured resistance is only 7K higher, which is not excessive because most of this resistance is in the power-supply circuits. You should never have selected the grid circuits as being at fault, since the voltage was closer to normal than in the other tube sections.

Read page 124 again and make another selection.

from page 99

YOUR SELECTION:

A. Horizontal amplifier, vertical amplifier, power supply, and cathode-ray tube.

To check the outputs of the first two of these circuit groups requires the use of another oscilloscope. A test signal is obtained by connecting the vertical a-c input to the line terminal, which provides a 3.15-volt, 60-cycle signal. The waveforms obtained at the outputs of the horizontal amplifier and the vertical amplifier are shown in figure 52.

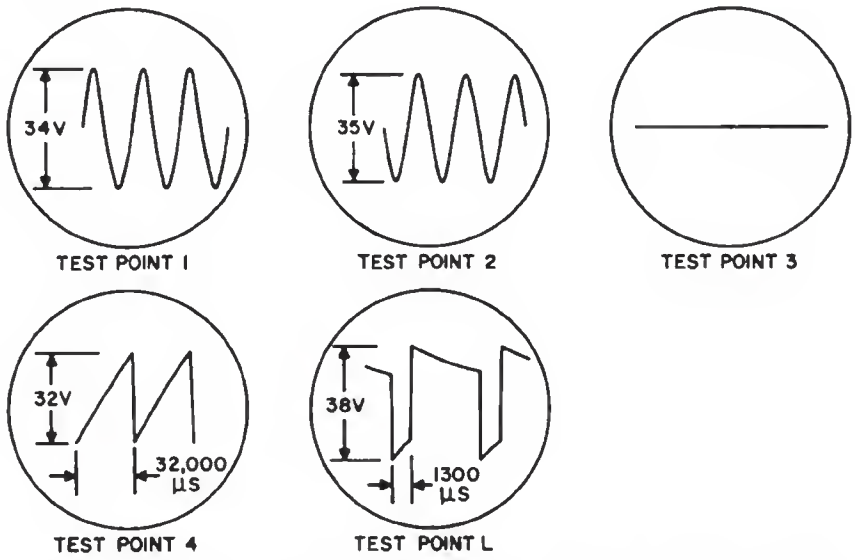

Figure 52. Vertical and Horizontal Amplifier Output Waveforms

The output of the cathode-ray tube is the visual pattern on the screen, which has been checked in steps 1 and 2. Therefore, no test is required to check the output of this circuit group.

Considering the data obtained at this point, which of the following circuit groups is faulty?

SELECTIONS:

A. Power supply. (Page 128)

B. Cathode-ray tube. (Page 84)

C. Horizontal amplifier. (Page 123)

from page 87

YOUR SELECTION:

B. The trouble is between test point N and the output of this circuit group.

Yes. By making a check at test point N, you have eliminated the cathode follower and attenuator circuits, and isolated the trouble to the first and second d-c amplifiers. This is a good example of the half-split method. An input bracket could have been placed at the input of the horizontal amplifier before making this test, because the symptom elaboration step proved that switching the horizontal attenuator from SWEEP to AC or DC inputs did not affect the outputs (an application of the switching technique). Now you can move this input bracket to test point N, and the trouble is bracketed between this point and the output.

Where should the next test be made?

SELECTIONS:

A. Test point P. (Page 139)

B. Test point O. (Page 100)

C. I am ready to go to step 6—failure analysis. (Page 92)

from page 94

YOUR SELECTION:

B. The trouble is located between test point M and the output of this circuit group.

Yes. The check at test point M confirms that the horizontal signal is satisfactory at this point; therefore, the trouble must be beyond this point.

However, this test point should not have been the first check within this circuit group. Only the cathode follower and part of the horizontal attenuator have been eliminated by this test.

Read page 116 again and select another test point.

from page 86

YOUR SELECTION:

B. There is no visual indication that the TS-O is operating.

This is a poor choice, since the POWER ON light indicates that power is being applied to the TS-O. However, since there is no indication on the screen, there is a definite trouble. Your original selection — there is no trouble symptom — was incorrect. Before attempting to observe a waveform on the oscilloscope, you should obtain a sweep on the screen of the cathode-ray tube.

Return to page 5 of the TS-O manual and study the operational techniques. Then return to page 79 of this lesson and select a more logical choice.

from page 119

YOUR SELECTION:

C. Horizontal amplifier.

Yes. After examining these waveforms, it should be obvious that the outputs of the horizontal amplifier are incorrect. Closing brackets can be placed at the outputs of this circuit group. Selecting all sub-functions which provide inputs to the cathode-ray tube has made it possible to check the latter while testing the outputs of the former. If all of the waveforms above had been correct, however, the trouble would have been isolated to the cathode-ray-tube circuit.

The power supply does not have to be tested, since one of the sub-functions it supplies (the vertical amplifier) is operating correctly, and the trouble is apparently in the horizontal amplifier.

You are now ready to employ the appropriate bracketing technique to the horizontal amplifier. Which type of signal path arrangement does this circuit group contain? Consult the servicing block diagram (page 53-54) of the TS-O manual.

SELECTIONS:

A. Feedback and convergent-divergent. (Page 134)

B. Switching and divergent. (Page 80)

C. Switching and convergent-divergent. (Page 116)

from page 100

YOUR SELECTION:

B. Second d-c amplifier, V107A and B.

Yes. The input to this circuit (test point 0) is satisfactory, and the outputs are incorrect. The input bracket should be moved from the last check point to the input of the second d-c amplifier, and then the brackets will enclose the faulty circuit. You have completed step 5—localizing trouble to the circuits—and you are now ready to proceed with the failure analysis step—the final isolation of a faulty part.

Figure 18, page 51-52, in the TS-0 manual is the over-all schematic diagram of the TS-0. You will need to consult this diagram. You may also find figure 10, page 37-38, of that manual helpful.

A complete description of the operation of the second horizontal d-c amplifier is given in paragraph 4, page 19, of the TS-0 manual. Study this paragraph before proceeding.

Since the trouble is isolated to one circuit, it is a good procedure to check the vacuum tube. This check, however, reveals that the 6J6 tube is satisfactory.

The next step is to remove the test signal from the a-c input terminals of the TS-0 and then check the voltage at the pins of V107. The voltage measurements for this vacuum tube are shown in figure 58.

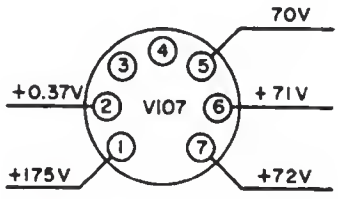

Figure 58. Second Horizontal D-C Amplifier Pin Voltages

(continued on the next page)

from page 124

Compare the measured values with the normal values on page 49-50 of the TS-O manual, and select the section of the faulty circuit in which you would expect to find the trouble.

SELECTIONS:

A. Grid circuits (pins 5 and 6). (Page 107)

B. Plate circuits (pins 1 and 2). (Page 112)

C. Cathode circuit (pin 7). (Page 133)

from page 83

YOUR SELECTION:

A. I have gained no additional information which would help me elaborate on the original symptom.

Wrong. The information is there — you are misinterpreting it. None of your manipulations changed the appearance of the screen, as shown on the fold-out. This lack of change provides additional information.

When you moved the horizontal attenuator control away from the SWEEP position, you removed the horizontal deflection voltage. With no horizontal or vertical deflection voltage, the screen should appear as shown in figure 49.

With this information in mind, return to page 83 and restudy the manipulation effects of each control. Then make a better selection.

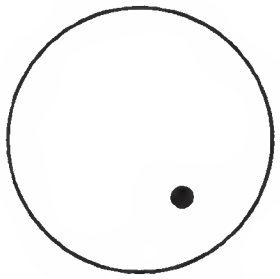

Figure 49. Spot with No Deflection Voltage Applied (Position may vary)

from page 133

YOUR SELECTION:

A. R141

No. R141 is a variable resistor, and the adjustment of this resistor affects the cathode resistance of V107. The 1K difference between the normal and measured resistance could easily be caused by this adjustment. Although the cathode voltage was low, it was not the tube section with the greatest deviation from normal. The low cathode voltage would be the result of decreased plate current, which could be caused by a fault in another section of the tube.

Read page 124 again and make another selection.

from page 119

YOUR SELECTION:

A. Power supply.

No. The outputs of the vertical amplifier are satisfactory, which proves that the low and medium supply voltages are present. The original symptoms could be caused by a faulty high-voltage supply, which furnished the high negative voltage for the cathode-ray tube. However, the test results indicate that the trouble is in a circuit group other than the power supply.

Read page 119 again and make another selection.

from page 137

YOUR SELECTION:

B. Power supply.

No. Perhaps you based this decision on the fact that all waveforms were smaller in amplitude than on the servicing block diagram. The deviations from normal are not excessive, considering the tolerances in resistor values, the gains of the tubes, etc. Besides, the original symptoms indicate that something has failed completely rather than merely below normal performance.

Your first mistake, however, was in selecting the group of possible faulty sub-functions. A faulty synchronization channel could not cause the observed symptom.

Read page 99 again and make another selection.

from page 86

YOUR SELECTION:

A. There is no waveform display on the TS-O screen.

This is certainly true. In order for the TS-O to perform its operational function, the combination of the time base voltage on the horizontal deflection plates and the voltage from the modulator output on the vertical deflection plates should give you a "picture" of the modulator output.

At this point you might think, "Well, the modulator is faulty and it isn't producing an output waveform." This might be true. However, look at the original conditions which existed before you applied the modulator output to the vertical input posts of the TS-O. These are given on the fold-out pages mentioned previously. These conditions definitely provide a sign of trouble in the TS-O which you should have recognized prior to applying the signal from the modulator unit.

Return to page 5 of the TS-O manual and study the operational techniques. Then return to page 79 of this lesson, study the symptoms, and select a more logical answer.

from page 116

YOUR SELECTION:

C. Test point P.

The oscilloscope waveform viewed at this test point is shown in figure 54.

Considering this information, which conclusion is most valid?

SELECTIONS:

A. The trouble is located between the input of this circuit group and test point P. (Page 136)

B. The trouble is in the second d-c amplifier. (Page 111)

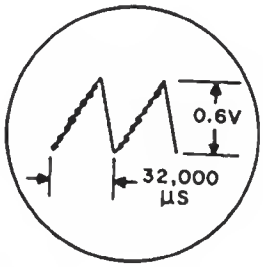

Figure 54. Waveform at Test Point P

from page 81

YOUR SELECTION:

B. Make additional checks of the power supply.

No. The output of the sweep oscillator is about 10% low; however, this is not excessive considering the tolerances of resistors and the variations in vacuum tubes. The fact that the sweep oscillator circuits are operating should have eliminated the power supply as a possible trouble.

Your selection of possible faulty sub-functions was not the most logical choice. It did not include every possible faulty circuit group, and it included one (sweep oscillator) which is not a likely source of trouble.

You should recall that the sweep oscillator functions to "sweep" the electron beam horizontally across the face of the cathode-ray tube. It does not determine whether a signal will reach the face of the cathode-ray tube.

Reread page 99 and select another answer.

from page 125

YOUR SELECTION:

C. Cathode circuit (pin 7).

To check the cathode circuit, a resistance check should be made at pin 7.

The resistance measured from cathode to ground is 4K.

Considering this information, which part is probably faulty?

SELECTIONS:

A. R141 (Page 127)

B. R142 (Page 97)

C. None of the parts in the cathode circuit. (Page 93)

from page 123

YOUR SELECTION:

A. Feedback and covergent-divergent.

No. There are no return loops in the horizontal amplifier. Therefore, it cannot be a feedback circuit arrangement. Actually, this circuit group has two separate signal paths, one through the intensity modulation amplifier (V105B) and one through the horizontal cathode follower and d-c amplifiers. There are three possible inputs to this latter signal path (the sweep oscillator output and the horizontal a-c and d-c inputs are selected by S102

Read page 123 again and select a better answer.

from page 103

YOUR SELECTION:

C. I should proceed to formulate a faulty unit selection with the information I have.

No. The TS-O is a single-unit equipment. According to our discussion in Lesson No. 4, you can skip the listing of probable faulty functions (step 3) when the set is not a multi-unit equipment.

Return to page 114 and study the results of your control manipulations very carefully. Then make another selection.

from page 131

YOUR SELECTION:

A. The trouble is located between the input of this circuit group and test point P.

No. The wave form shown is quite similar to the one in the servicing block diagram, although test point P is in a secondary signal path which contains only the high-frequency component of the horizontal signal. When selecting a test point to isolate the trouble area, you should always keep in mind that each test should either eliminate or verify the maximum number of circuits.

Read page 116 again and select another test point.

from page 99

YOUR SELECTION:

C. Vertical amplifier, synchronization, cathode-ray tube, and power supply.

To check the outputs of the first two of these circuit groups requires the use of another oscilloscope. A test signal is obtained by connecting the vertical a-c input to the LINE terminal which provides a 3.15-volt, 60-cycle signal. The waveforms obtained at the outputs of the vertical amplifier and the synchronization channel are shown in figure 51.

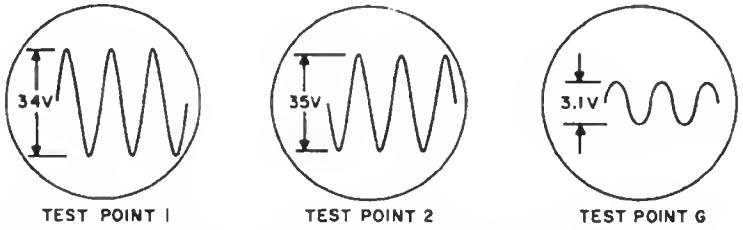

Figure 51. Vertical Amplifier and Synchronization Output Waveforms

The output of the cathode-ray tube is the visual pattern on the screen which has been checked in steps 1 and 2. Therefore, no test is required to check the output of this circuit group.

The power supply can be checked by measuring the output voltages. The high voltage can be measured at R169, which is a convenient test point. In this case it reads -560 volts, which is correct. The outputs of both the low-voltage supply and the high-voltage supply are used by the vertical amplifier; therefore, the operation of this circuit group should be a definite indication of the operation of the low-voltage and medium-voltage supplies.

Considering the data obtained at this point, which of these circuits groups is probably faulty?

SELECTIONS:

A. Vertical amplifier. (Page 106)

B. Power supply. (Page 129)

C. None of these circuit groups are at fault. (Page 108)

from page 100

YOUR SELECTION:

C. There is not sufficient information to determine the faulty circuit.

Wrong. There certainly is sufficient information to isolate the trouble to one circuit. The trouble has been isolated to two circuits, and test point O is in the main signal path between the two circuits; therefore the signal at this test point definitely indicates which of the two circuits is faulty.

Read page 100 again and make another selection.

from page 120

YOUR SELECTION:

A. Test point P.

The oscilloscope waveform viewed at this test point is shown in figure 56.

Considering this test result, which circuit is faulty?

SELECTIONS:

A. First d-c amplifier, V106A and B. (Page 105)

B. Second d-c amplifier, V107A and B. (Page 115)

C. There is not sufficient information to determine the faulty circuit. (Page 82)

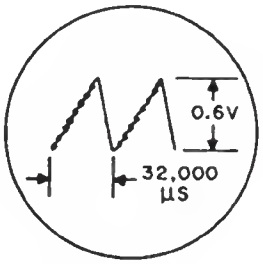

Figure 56. Waveform at Test Point P

from page 112

YOUR SELECTION:

B. R146.

Good. This is indicated by the infinite resistance reading at pin 2, which should be 130K, and the voltage reading of almost 0. The slight positive potential (+0.37 volts) is due to the Edison effect, which is normal when measuring the plate voltage of a tube with an open plate resistor. The low cathode voltage is caused by the absence of current in the plate 2 circuit.

The ohmmeter leads should be placed directly across R146 to make certain that the failure is in the resistor and not a faulty connection. This test reveals that R146 is open.

Now that the faulty component has been isolated, we must verify that this trouble would cause the indicated symptoms.

Consulting the schematic diagram on page 51-52, of the TS-0 manual, we can determine the symptoms which should be produced by the open plate resistor. Immediately, we can see that the d-c plate voltage which is normally directly coupled to the left horizontal deflection plate of the cathode-ray tube will not be present. However, there is a d-c voltage (+175 volts) present on the right horizontal deflection plate. This would cause the electron beam to be deflected toward the plate, with the large d-c voltage preventing it from reaching the screen.

For this reason the trouble symptom associated with an open plate resistor (R146) would be "no spot". The imbalance of deflection voltages is so great that adjusting the positioning controls cannot bring the spot back on the screen.

You might ask, however, "Why is the output of the other half of this tube much smaller than normal?" If you will notice that the two triodes in this tube share the same cathode and cathode resistors, it should become obvious that the cathode bias is a result of the combined plate currents of the two triodes. If one triode has an open plate circuit, the bias will be reduced and the other tube will conduct much more heavily than normal, as evidenced by the low plate voltage. This changes the operating point of the tube and causes the reduced output waveform.

(continued on the next page)

This, then, exactly fits the symptoms encountered during this trouble-shooting project.

Now, let's ask the question, "What could cause R146 to be open?" The answer may simply be mishandling of the TS-0, or the loosening of a connection over a long period of time. A visual inspection usually will determine the difference between a mechanical failure and an electrical failure. Electrical failure of this resistor could result from power-supply surges, a defect in the resistor, or a faulty tube, V107. It would be a very good idea to check this tube in a tube tester to make sure that it has not been damaged.

With the completion of these precautionary checks and any repairs or replacements indicated by them, you can check the operation of the TS-0 again and then fill out the Electronic Equipment Failure/Replacement Report form, and return the TS-0 to operational status.

U. S. GOVERNMENT PRINTING OFFICE 1965 O - 778-950